TURBIDITY ESTIMATED SEDIMENT LOADS AT DEER CREEK EAST OF LELAND, MISSISSIPPI

By Michael S. Runner
U.S. Geological Survey, Pearl, Mississippi

INTRODUCTION

The Mississippi District of the U. S. Geological Survey (USGS), in cooperation with the Mississippi Department of Environmental Quality-Office of Land and Water Resources (MDEQ-OLWR), the U.S. Fish and Wildlife Service (USF&WS), and the Yazoo Mississippi Delta Joint Water Management District (YMD), began collecting stream stage, discharge, turbidity and other water-quality data, and suspended-sediment concentration data at Deer Creek East of Leland, Mississippi, in December 2001. The purpose of this study is to collect data for the evaluation of the aquatic health of Deer Creek as part of the Deer Creek Restoration Project.

This paper presents the results of an analysis to test the use of continuous-turbidity data as a surrogate for suspended-sediment concentrations. Sensors that measure the bulk optical properties of water, such as turbidity, have been used to provide a continuous time series estimate of suspended-sediment concentrations with a quantifiable certainty (Schoellhamer, 2001). Christensen, and others (2000) used simple linear regression to develop a site-specific model using turbidity to continuously estimate suspended-sediment concentrations. The generated regression equation explained about 93 percent of the variance in suspended-sediment concentrations.

SITE DESCRIPTION

Deer Creek is in the northwestern part of Mississippi in the Mississippi Alluvial Plain, an area known locally as the Delta (fig. 1). The headwaters of Deer Creek are Lake Bolivar at Scott, Mississippi. The stream flows south through the Delta into the Yazoo River near Vicksburg, Mississippi. The drainage area of Deer Creek for the monitoring site (gage) is 80 mi^2; a significant part of the land adjacent to the stream drains away from the stream and contributes little or no surface-water runoff.

Streamflow at the monitoring site is controlled by a weir 200 feet downstream of the gage. Water is pooled behind the weir at low discharge. Stream velocities at the site are low, even during periods of high discharge [0.69 ft/s (feet per second) at 622 ft^3/s (cubic feet per second)]. The low stream velocity limits the ability of the stream to transport large sediment particles. Most of the suspended sediment in transport is fine grain material (<0.062 mm) and little-to-no sand is in transport at the site. A relation between turbidity and suspended-sediment concentration was possible because of the predominance of fine sediments in transport at Deer Creek.

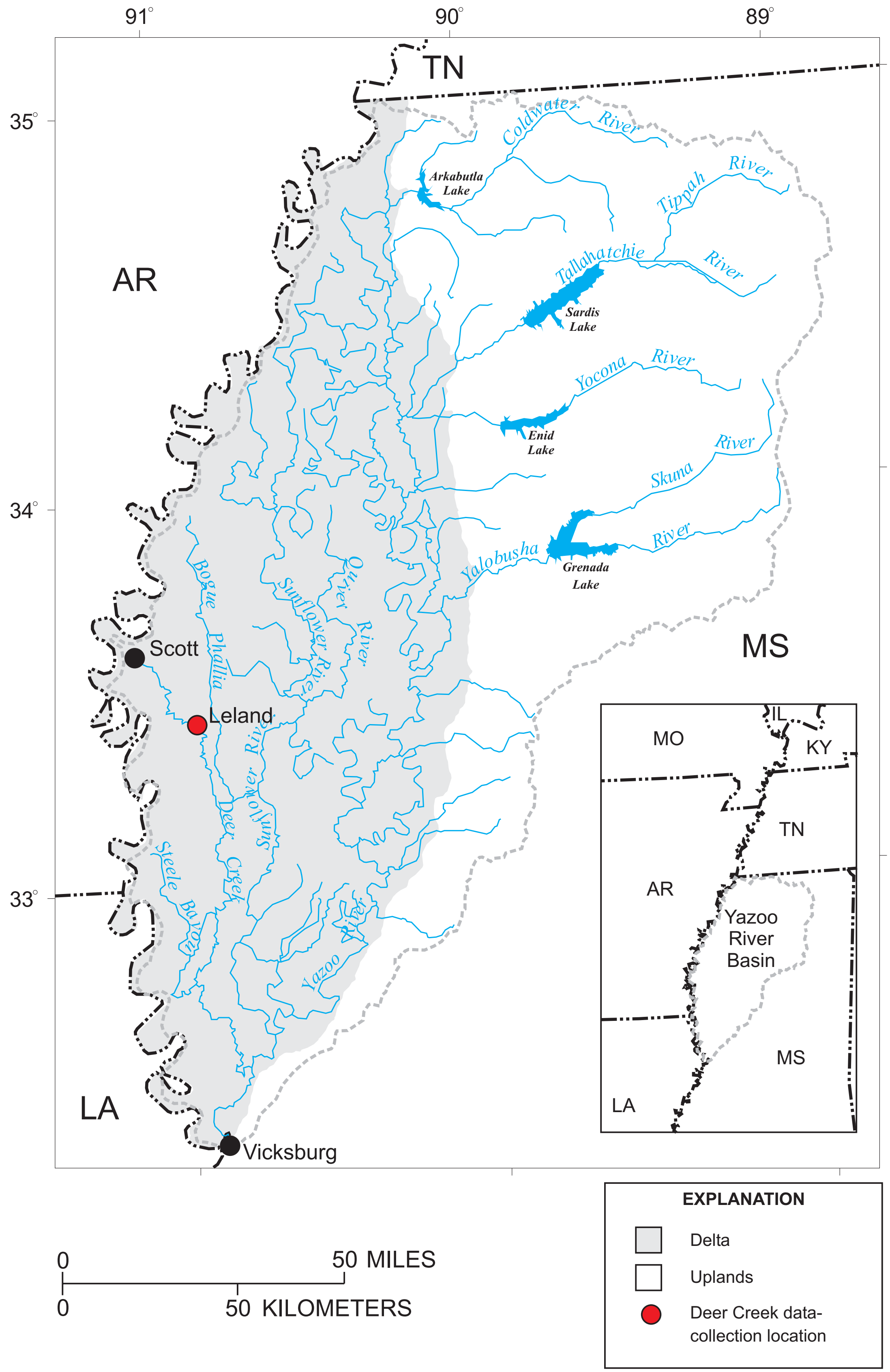

Figure 1. Location of Deer Creek East of Leland, Mississippi, data collection site.

DATA COLLECTION

Stream stage and turbidity and the other water-quality properties are measured and recorded every 30 minutes and transmitted via satellite to the USGS Mississippi District office every 4 hours. The data are made available through the Mississippi District real-time data web page. Suspended-sediment samples are collected every 2 weeks, along with cross-section measurements of the water-quality properties.

Stream stage is measured and recorded by using a non-submersible pressure transducer. Discharge measurements have been made by using Price AA velocity meters and an acoustic Doppler current profiler (ADCP) over a range in stream stage to define the stage/discharge relation (Rantz and others, 1982). A YSI-6820 water-quality monitor with a model 6026 turbidity probe is installed in a pipe secured to the downstream side of the right pile group and measures temperature, pH, dissolved oxygen, specific conductance, and turbidity.

The site is visited every 2 weeks to check the calibration of the water-quality monitor by using techniques described in the USGS publications "National Field Manual for the Collection of Water-Quality Data" (Wilde and others, 1998) and "Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Site Selection, Field Operation, Calibration, Record Computation, and Reporting" (Wagner and others, 2000). Several measurements are made within the cross section to determine a cross-sectional average for each of the five water-quality properties. Also during each site visit, a depth-integrated, equal-width-increment suspended-sediment sample is collected by using techniques described in "Field Methods for Measurement of Fluvial Sediment" (Edwards and Glysson, 1999), to determine the average suspended-sediment concentration for the stream. Sediment samples are sent to the USGS sediment laboratory in Baton Rouge, Louisiana, for analysis.

DATA ANALYSIS

The standard method for collecting and publishing daily sediment values requires frequent manual and/or automatic sampling, laboratory analysis of the samples, and analysis of large data sets and is described in the USGS publications "Computation of Fluvial-Sediment Discharge" (Porterfield, 1972), and "Fluvial Sediment Concepts" (Guy, 1970). The computations rely heavily on the hydrographer's judgment and experience in estimating data when sediment-concentration data are not available. The method described in this paper is less subjective than the standard method.

The analyses of water-quality data are done according to the guidelines found in USGS publications (Wagner and others, 2000). Originally, the instantaneous turbidity data were planned to be adjusted to the cross-section average by using coefficients computed from the cross-sectional turbidity measurements. However the relation between the instantaneous turbidity data and suspended-sediment concentrations, and the relation between the EWI turbidity measurements and suspended-sediment concentrations was found to be almost statistically identical. Therefore, values of instantaneous turbidity were used for the correlation. The model developed for this study for estimating suspended-sediment concentrations is site and instrument specific and can be only be used with turbidity data from the same model turbidity probe.

RESULTS

Twenty-one suspended-sediment samples with concurrent cross-sectional turbidity measurements were made from December 2001 through September 2002. Suspended-sediment concentrations ranged from 53 to 569 mg/L (milligrams per liter). Measured turbidity ranged from 22 to 721 NTU (nephelometric turbidity units). Instantaneous turbidity measured by the continuous monitor at the times the sediment samples were collected ranged from 21 to 730 NTU. Stream discharges at the times of sample collection ranged from 0 to 745 ft^3/s. The computed stream discharge ranged from 0 to 800 ft^3/s. Stream discharge, turbidity, and suspended-sediment concentration data at the time of sample collection are summarized in table 1.

Continuous stream discharge and turbidity hydrographs for Deer Creek show that there is a lag between the time of peak discharge and the time of the peak turbidity, with the peak turbidity occurring during the falling limb of the discharge hydrograph (fig. 2). A comparison of the suspended-sediment concentration and instantaneous discharge illustrates the poor relation between the two (fig. 3). However, a plot of the suspended-sediment concentration and the instantaneous turbidity of the stream indicates a good relation (fig. 4). Two equations describing the relation between the suspended-sediment concentration and turbidity were developed. The models which gave the best fit to the data and their respective levels of significance are (1) a second-order polynomial ($R^2 = 0.97$), and (2) a linear equation ($R^2 = 0.94$):

$$Y = 0.0005X^2 + 0.3123X + 63.994 \tag{1}$$

$$Y = 0.6244X + 40.72 \tag{2}$$

Where Y = suspended-sediment concentration (mg/L), and X = turbidity (NTU). Both models were used to compute the sediment loads for Deer Creek by using the following equation:

$$S= Q*C*0.0027$$

Where S is the sediment load, in tons; Q is the mean-daily discharge (ft^3/s); C is the mean sediment concentration (mg/L) as estimated by the models; and 0.0027 is a conversion factor.

The model based on the polynomial equation computed a total load of 18,300 tons for the study period. The model based on the linear equation computed a total load of 19,400 tons. Neither of these totals considers the load transported during the 26 days of missing or bad turbidity data that occurred during the study period. Loads for these days would

Table 1. Discharge, cross section turbidity, unit value turbidity, and suspended sediment concentrations for data collected at Deer Creek East of Leland, Mississippi, December 2001 through September 2002 (ft^3/s, cubic feet per second; ntu, nephelometric turbidity units; mg/L, milligrams per liter; --, no unit value data available)

Sample date and time	Discharge (ft^3/s)	Cross-section turbidity (ntu)	Continuous turbidity (ntu)	Suspended-sediment concentration (mg/L)
12/11/01 13:15	446	174	155	131
12/18/01 18:30	745	249	250	164
1/16/02 11:30	59	181	--	142
1/31/02 12:15	592	424	420	249
2/13/02 11:30	172	305	240	187
2/26/02 15:00	142	330	290	217
3/13/02 11:15	63	289	240	195
3/26/02 12:30	251	355	336	221
4/10/02 11:30	240	514	505	334
4/25/02 11:15	40	49	62	61
5/7/02 11:45	140	721	730	566
5/24/02 11:15	8.7	106	130	111
6/5/02 12:00	2.9	63	78	92
6/20/02 11:15	0	32	35	54
7/2/02 13:45	9.8	30	53	62
7/16/02 13:15	14	22	33	53
7/31/02 12:00	12	27	22	65
8/15/02 11:30	5.8	50	44	124
8/28/02 10:30	0.78	35	31	73
9/11/02 11:15	0	55	51	93
9/24/02 12:30	1	34	21	86

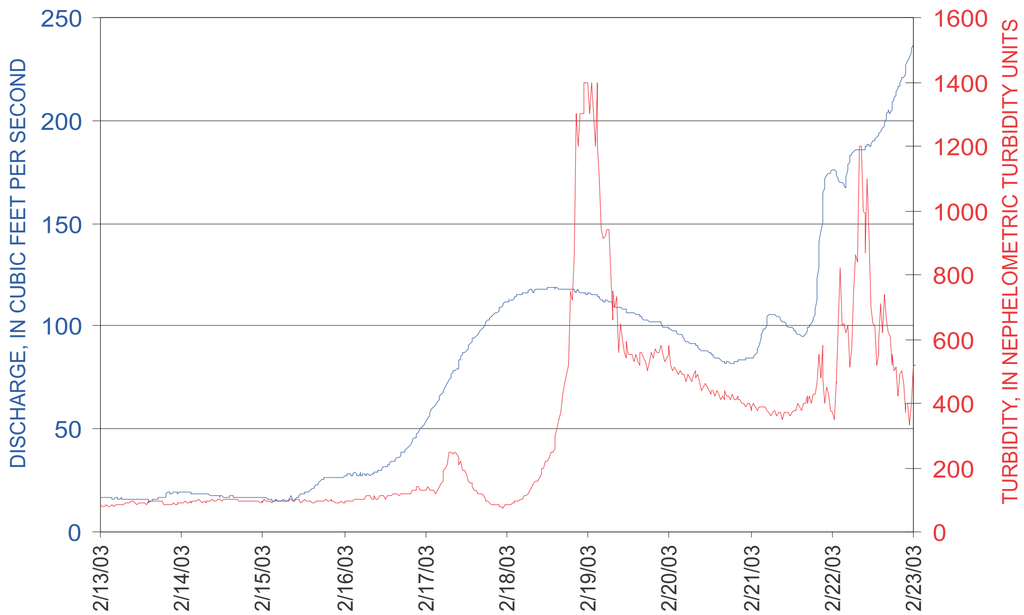

Figure 2.- Stream discharge and turbidity data for Deer Creek East of Leland, Mississippi, February 13 through February 23, 2003.

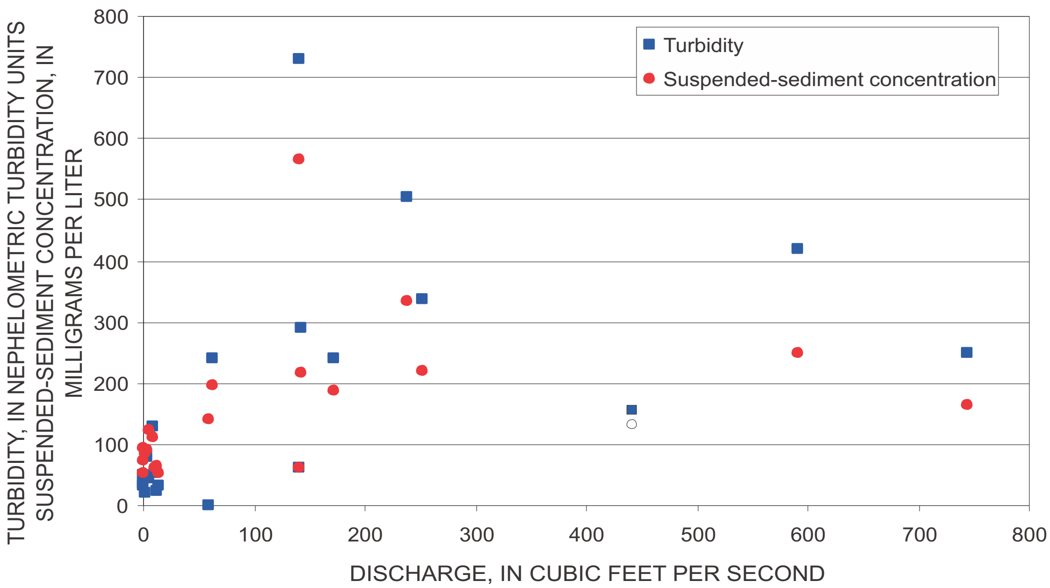

Figure 3.- Instantaneous turbidity and suspended-sediment concentration relation with stream discharge for Deer Creek East of Leland, Mississippi, December 2001 through September 2002.

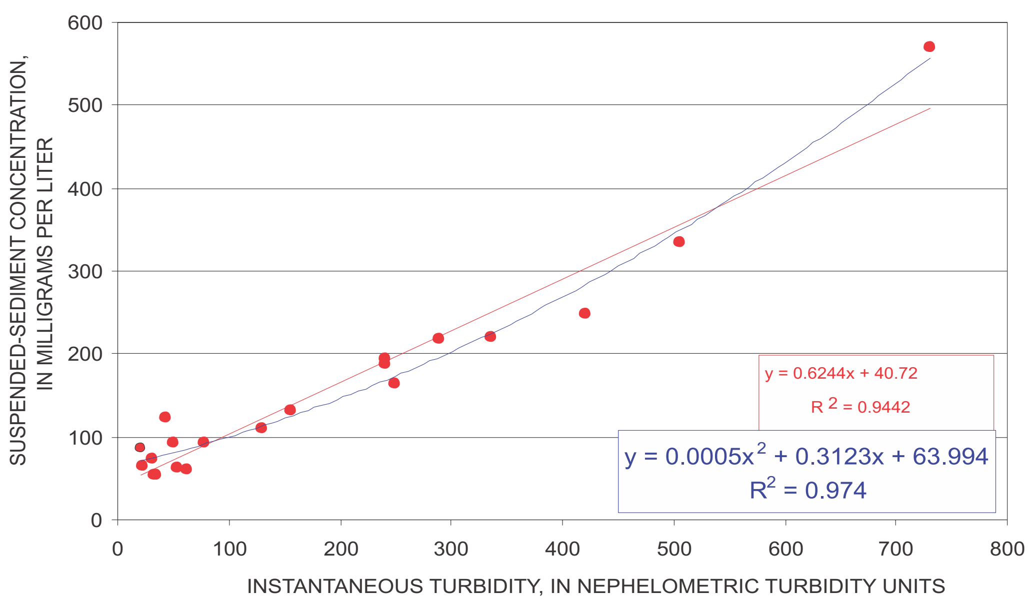

Figure 4.- Suspended-sediment concentrations and instantaneous turbidity relation for Deer Creek East of Leland, Mississippi, December 2001 through September 2002.

have to be estimated. The 1100-ton difference between the two models represents 6 percent of the total load for the study period.

These models are preliminary to a final model that will be developed after more samples are collected and may more accurately represent suspended-sediment concentrations in the stream. These models explain at least 94 percent of the variability of the suspended-sediment concentrations.

SUMMARY

The Mississippi District of the USGS has been collecting stream stage, turbidity, and suspended-sediment data on Deer Creek East of Leland, Mississippi, since December 2001. Stage and turbidity data are recorded every 30 minutes. Suspended-sediment samples are collected every 2 weeks. Data collected from December 2001, through September 2002, were used to compute suspended-sediment loads for Deer Creek based on the stream discharge and turbidity data, and the suspended-sediment concentrations. A model based on a polynomial equation and a model based on a linear equation were developed to describe the relation between the instantaneous-turbidity data and suspended-sediment concentrations at the site. Concentrations estimated by the models were then used, along with the computed discharges, to compute suspended-sediment loads. The model based on a polynomial equation computed a total of 18,300 tons of sediment were transported in Deer Creek for the days where a daily mean turbidity value was computed. The model based on a linear relation between instantaneous turbidity and suspended-sediment computed a total load of 19,400 tons for the days where a daily mean turbidity was computed.

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